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FISHING CONDITIONS south of THE MARSHALL ISLANDS

SPECIAL SCIENTIFIC REPORT: FISHERIES No. 43

UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE

EXPLANATORY NOTE

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Washington, D. C.
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United States Department of the Interior
Oscar L. Chapman, Secretary
Fish and Wildlife Service
Albert M. Day, Director

Special Scientific Report - Fisheries

No. 43

FISHING CONDITIONS SOUTH OF THE MARSHALL ISLANDS

Translated from the Japanese language by

W. G. Van Campen
Pacific Oceanic Fishery Investigations

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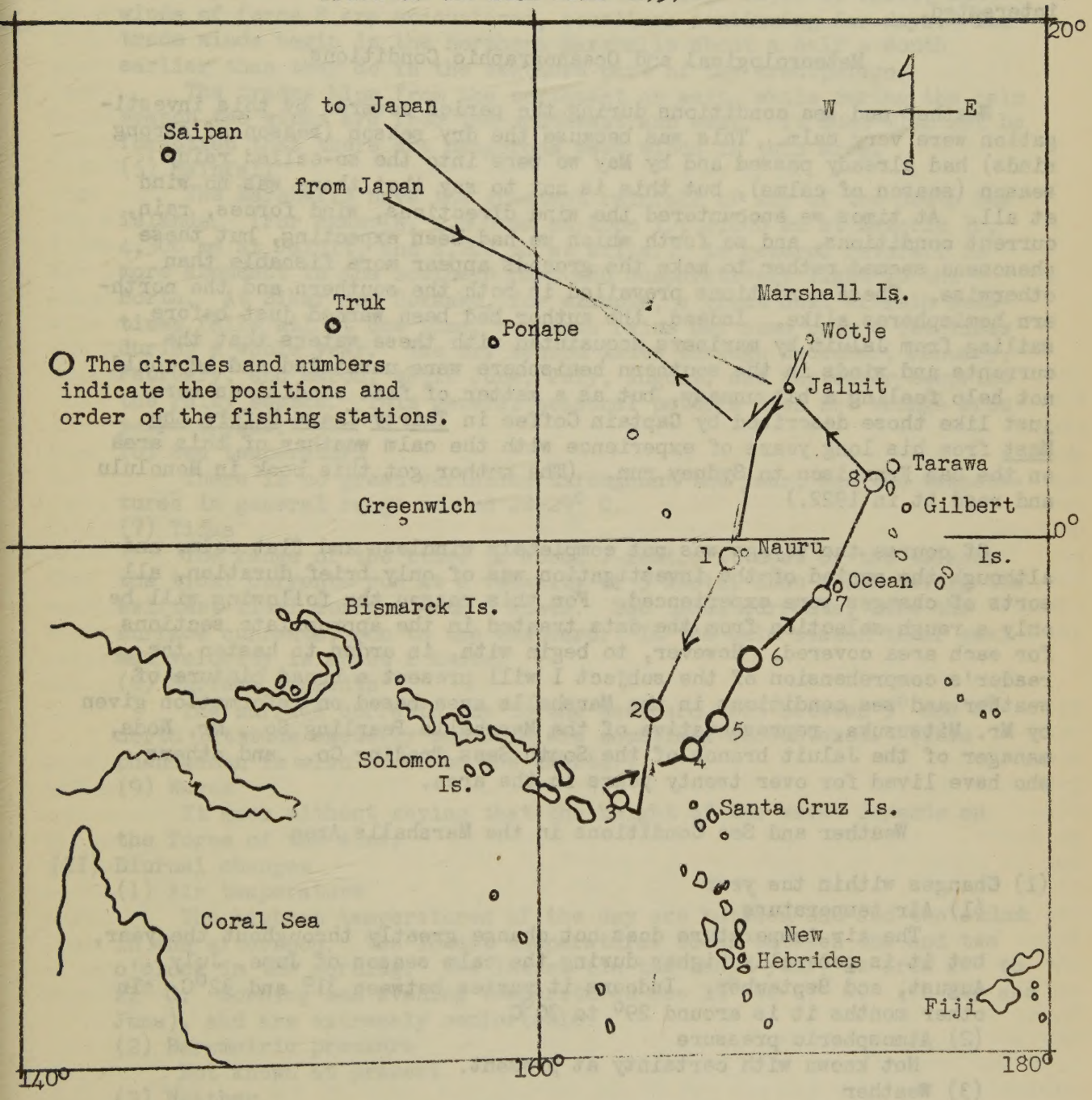
1/ From South Sea Fisheries [Nanyō Suisan], No. 58, 6(3), March 25, 1940. pp. 12-19; No. 59, 6(4), April 25, 1940. pp. 14-25; No. 60, 6(5), May 25, 1940. pp. 9-15. Published by the South Sea Fisheries Association, Incorporated.

Track of the Ebon Maru 1939



○ The circles and numbers indicate the positions and order of the fishing stations.

Fishing Conditions South of the Marshall Islands

This paper is based on reports of the investigations conducted aboard the Company's research vessel Ebon Maru in the waters south of the Marshalls from March to June, 1939. In view of the paucity of research data from this area, the editor of this journal has prevailed upon the author to have it printed here for the information of persons in the industry who may be interested.

Meteorological and Oceanographic Conditions

Weather and sea conditions during the period covered by this investigation were very calm. This was because the dry season (season of strong winds) had already passed and by May we were into the so-called rainy season (season of calms), but this is not to say that there was no wind at all. At times we encountered the wind directions, wind forces, rain, current conditions, and so forth which we had been expecting, but these phenomena seemed rather to make the grounds appear more fishable than otherwise. These conditions prevailed in both the southern and the northern hemispheres alike. Indeed, the author had been warned just before sailing from Jaluit by mariners acquainted with these waters that the currents and winds in the southern hemisphere were unsettled and he could not help feeling a bit uneasy, but as a matter of fact conditions were just like those described by Captain Coffee in Thirty Years Before the Mast from his long years of experience with the calm weather of this area on the San Francisco to Sydney run. (The author got this book in Honolulu and read it in 1922.)

Of course the voyage was not completely windless and flat calm, and although the period of the investigation was of only brief duration, all sorts of changes were experienced. For this reason the following will be only a rough selection from the data treated in the appropriate sections for each area covered. However, to begin with, in order to hasten the reader's comprehension of the subject I will present a broad picture of weather and sea conditions in the Marshalls area based on information given by Mr. Mitsuzuka, representative of the Marshalls Pearling Co., Mr. Noda, manager of the Jaluit branch of the South Seas Trading Co., and others who have lived for over twenty years in the area.

Weather and Sea Conditions in the Marshalls Area

(I) Changes within the year

(1) Air temperature

The air temperature does not change greatly throughout the year, but it is generally higher during the calm season of June, July, August, and September. Indoors it varies between 31° and 32°C. In other months it is around 29° to 30°C.

(2) Atmospheric pressure

Not known with certainty at present.

(3) Weather

During the months of November, December, January, and February when the trade wind blows there is little cloud cover, but it

increases in May, June, July, August, and September until cloud cover of 8 or 9 is not unusual.

(4) Wind

Winds of force 6 occur in every month of the calm season but only before and after squalls. During December, January, and February the trade winds maintain a rather high level of force, and winds of force 8 are encountered, sometimes continuing for days. The trade winds begin in the northern Marshalls about a half a month earlier than they do in the southern part of the archipelago.

The trades blow from the northeast or east, while during the calm season the winds are from the southeast and east. It must also not be forgotten that there are dangerous west winds in this area.

(5) Rainfall

The Marshalls have the greatest rainfall of any of the South Sea islands. (For example, 4,600 mm at Ebon I., 4,600 mm at Namorik I., 4,300 mm at Jaluit, and 4,200 mm at Mille.) In general rainfall is more abundant in the southern part and comparatively light in the north. At Bikar and Pokaaku, for example, a great deal of rain sometimes falls all at one time, but such rains may come only a few times during a whole year. The dry season lasts through December, January, February, and March, while June, July, August, and September comprise the rainy season. This general seasonal pattern does not change from year to year.

(6) Sea temperature

There is no great variation throughout the year, and the temperatures in general range around 28-29° C.

(7) Tides

The range of the tides is about 7 feet. At most of the islands the tidal currents run at a velocity of 5 knots, Ebon Atoll having the swiftest tidal current with 6 knots. The tidal currents, like the surface currents, run to the westward. In the calm season their maximum velocity is about 2 knots.

(8) Surface currents

The surface currents run to the westward, but between 3° and 8° north latitude easterly currents are sometimes encountered. (This phenomenon is also shown on the charts.)

(9) Waves

It goes without saying that the height of the waves depends on the force of the wind.

(II) Diurnal changes

(1) Air temperature

The highest temperatures of the day are between one and two o'clock in the afternoon. The lowest temperatures occur between one and two o'clock in the morning. The lowest (in the whole year) is from 20° to 21° C. Morning and evening temperatures are 26° to 27° C. (in May and June), and are extremely comfortable.

(2) Barometric pressure

Not known at present.

(3) Weather

Clear skies generally prevail in the dry season, but during the rainy season it is thought that there is little change in the amount of cloud cover throughout the day.

(4) Wind

The wind force appears to increase at high tide and to lessen at low tide. At other times moderate winds prevail. The direction of the wind is as described under annual changes, and there are no local peculiarities in this regard.

(5) Rain

The time of day at which rain falls varies.

(6) Sea temperature

The sea water temperature generally rises and falls directly following upon changes in the air temperature.

(7) Tides

There is probably no need for special explanation.

(8) Surface currents

Same as preceding item.

(9) Waves

It goes without saying that the height of the waves depends on the force of the wind.

Well, the Marshall islands, which are located in the northern latitudes, are in general as described above, but what of the seas south of the archipelago which were covered by the investigations described in this paper? To begin with, in the area between Jaluit and Ebon (see the plate showing the track of the Ebon Maru for the positions of these atolls) the wind came steadily from the east-northeast with rather high forces of around 3 or 4. Cloud cover was from 9 to 10 and the color of the sea was unfavorable. It rained occasionally. While we were anchored at Ebon there were frequent rain storms of considerable violence. At this same island the tidal current in and out of the lagoon ran at around 6 knots and the comparatively fast motor boat which the Ebon Maru carried (speed about 7 knots) had a hard time making headway against it.

From Ebon Atoll we took a course to the south-southwest and crossed the Equator. Northeasterly winds of force 2 to 4 blew continuously all the way to British-controlled Nauru I. (also known as Pleasant I.). (Of course below the Equator the wind force lessened abruptly.) Rain squalls from time to time cooled us off, and it was truly a tranquil voyage. Cloud cover was comparatively great. There is a fixed light (lighthouse) on Nauru I. In the light of dawn this island could not be clearly seen, but it appeared to be made up of a number of comparatively flat islets and it is thought to comprise a fairly large area. An oceanographic station was run several miles to the west of the island (see the table of observations in the next number). Perhaps because of the proximity to the island the transparency of the water was low and there was an abundance of microscopic life in the water. The difference between the air and water temperatures was comparatively slight. There was almost no vertical variation in the sea water temperatures down to 75 meters (at subsequent stations we took the temperatures down to 100 or 200 meters, but there was still little variation), and the current ran to the west with a speed of about 1 knot. There was a slight ground-swell.

From the waters west of Nauru we continued for two days and nights on our course to the south-southwest to a point about 6° south latitude

and 164°30' east longitude. On the way the wind blew from the northeast with forces from 3 to 4 and the seas ran rather high. The sky was covered with broken clouds and there was lightning over a rather broad area but we heard no thunder. There was no rain either. Thereafter the wind shifted to the south-southwest with a force of 2, and we were visited from time to time by fierce squalls. In a short while a fine rain began to fall and the weather became somewhat milder. The currents were just as described hereinafter in the sections on the various fishing grounds; in the Equatorial Counter-current it is not unusual to meet with current speeds of one and one-half knots. At this position we encountered east-northeasterly currents with a speed of one knot. Near Nauru I. we had seen masses of clouds but they were at comparatively high levels and the total cloud cover was small, the air temperature was high, the seas were not very large, and the general impression was one of fine weather, but at this position the cloud cover was 10, the clouds hung low, the wind was strong, and conditions were bad enough to make one think that one was encountering one of the storms of this area. There were, however, three or four birds circling about near the water, and they helped to lessen somewhat our apprehensions about the weather.

Our vessel then ran for another two whole days and nights to a position between the Solomons and the Santa Cruz group. After resting (hove-to) for one night we sighted Stewart I. (This island is also extremely low and is located somewhat to the east of its charted position.) Immediately thereafter we turned our course back to the northeast. On the way southward the cloud cover was 10, there was no wind, the sea was almost flat calm, and it grew colder, but after we turned northeast again the weather gradually was restored to normal, the wind and the current were both generally easterly, the wind force was from 3 to 4, the current velocity was from 1 to 2 knots, cloud cover was 7 to 9, and lightning was seen far away from time to time.

From Fishing Station 6 the vessel proceeded toward British-controlled Ocean I. On the way north we found the current running strongly to the eastward (Equatorial Counter-current). For a number of reasons we ran our seventh fishing station south of Ocean I. On our way to this station the mornings and evenings were completely windless and sea conditions reminded one of the Inland Sea of Japan. When we first arrived at this station the cloud cover was 6, the wind force was 2, the wind was southeasterly, and the current ran east at 2 knots, but after we had set the lines a squall came on accompanied by a wind of force 5 and I and most of the crew were able to cleanse our bodies in a natural shower-bath lasting about forty minutes.

Our vessel then headed north-northwest so that we could take a look at Ocean I. for our information. We circled the island at a distance of 3 or 4 miles and, the weather being extremely fair at the time, we were able to observe clearly the topography of the island. It is shaped like a bun and gives one the impression of being a very pleasant place to live.

We then headed for Tarawa in the British-controlled Gilbert Is., proceeding east-northeast across the Equator. The wind blew from the northeast with forces of 2 and 3, and the cloud cover was 10, but there was no difficulty in navigating. Observations made about 20 miles west of Tarawa showed that both the wind and the current were east-northeast, in other words, we were heading into a one and one-half knot current and a wind of force 2. There was a great deal of microscopic life in the water. It is further worthy of note that the sea water temperature was slightly higher than the air temperature. This sort of phenomenon has been met with many times before and it is thought to occur quite frequently at morning and evening at many positions in the far southern latitudes.

We were going to put in to Tarawa and let the crew go ashore, but we received a radio message from the Company in Tokyo ordering us to cancel these plans and return to Japan. We therefore returned directly to Jaluit. During the more than 36 hours which this run required the wind blew continuously from the starboard beam, but the wind force was generally low and it did not cause us much trouble.

A point which must be recorded is that during the period described above we were unfortunately unable to operate by moonlight.

Fishing Conditions

Our principal catch was expected to consist of various species of tuna and as gear for taking these fish we carried 250 baskets of longlines. A great deal of fishing gear of other types was also made ready so that we would be fully prepared to carry out fishing operations, but all that we actually used were longlines, trolling lines, and auxiliary fishing gear.

The species taken were yellowfin, which were most numerous in the catch, big-eyed tuna, spearfish, flat-headed sharks [Scoliodon sp.] skipjack, and dolphin. Not even one cybiid was taken on the trip. In my past experience I have seen many sharks taken on longlines and have also seen many of the tunas taken on such lines damaged by shark-bite, but on this voyage we had only two or three shark-bitten fish. I think that more sharks could have been taken by harpooning them from the deck as they swam alongside the ship. It may be, however, that few sharks migrate into these waters at this time of the year.

Skipjack were taken at all stations on the trolling lines and a few were caught on the longlines, but in general they did not seem to surface like the schools in the northern hemisphere. Schools were seen on the surface only two or three times. However, as noted above, skipjack were taken at all positions in quantities sufficient for our galley, and consequently they are thought to occur in these waters to some degree, but nothing at all is known of their migratory pattern. Some of the skipjack which were taken had their bellies swollen and differed slightly from those which I have seen in the past. When we cut them open we found that some of them had eaten two or three very small skipjack.

Yellowfin, big-eyed tuna, and spearfish were sometimes all taken on the same line, but a peculiarity of the fishing situation which we encountered on this trip was the way in which at times large numbers of yellowfin would be taken while at other times the spearfish predominated. It almost seemed as if the fish were schooling by species. At the seventh fishing station 29 yellowfin were taken and no other fish were caught. The fish were all on the forward half of the longline, hardly any being taken on the after section. The fish were all of a size, ranging from 9 to 10 kan [1 kan = 8.27 pounds] in weight. In the case of the spearfishes, those of slightly over 10 kan were thought to have some tendency to school. At our last fishing station off the Gilbert Is. we took one lone giant of 43 kan, but we were never able to raise another of similar size.

Only one dolphin was taken on the trolling lines.

In the following paragraphs I will describe in detail the fishing situation and related matters for each station from the time we left Jaluit, but if the reader is deeply interested in fishing conditions in this area I would like to have him consult the account of the exploratory fishing done by the training ship Hakuō Maru of the Fisheries School of the Ministry of Agriculture and Forestry in the Solomons in 1936. This is the only fisheries exploration which has been carried out in these waters in the past.

After leaving Jaluit we hooked two skipjack on the trolling lines near Ebon I., but they both got away. These were undoubtedly island skipjack.

The day after leaving Ebon (May 5) we got another on the trolling line in the morning but it too got away. At 10:00 A.M. we hooked one, and at 12:30 P.M. we hooked two (one of which got off). At 2:00 P.M. we took two fish weighing from 900 momme [7.45 pounds] to 1 kan 100 momme [9.1 pounds]. At this time we sighted a school of porpoise mixed with sharks [whales ?] near our starboard side and from these circumstances it was thought that this particular area is rich in all forms of marine life. Beginning at 5:40 A.M. on the 6th we set out 60 baskets of line west of Nauru I. (Except for the third set, where we used 50 baskets, all of our other trials were made with 60 baskets, which was a suitable amount of line for an experimental set. If we had wanted to catch fish in large quantities we would have had to find a good spot by exploratory fishing and then set a large number of baskets of line and remain there for several days. We tried to avoid causing the crew unnecessary work.) There were absolutely no indications by which we could judge the prospects for success at this station, but as it turned out we had good luck on our first set and took 6 spearfish and 3 sharks. Two days later on the 8th at 4:00 A.M. we began our second set. We took 14 yellowfin, the first which we had caught; we also took 10 sharks and two of the yellowfin were shark-bitten.

At the time of the first set the weather appeared to be favorable, while at the second set it was somewhat stormy and rainy. On the first

set, but not on the second, we hauled in the lines after the sun had risen. Our experience in the first set indicated that the fish were probably rather deep, somewhat below 60 meters, but the branch lines of our longlines, being of the new type, were not that long. For this reason we took only spearfish and sharks, which swim at comparatively shallow levels. In our second trial the weather and sea conditions seem to have been such as to cause various sorts of fish to swim near the surface. We saw birds flying in the area and were able to predict in advance the kinds and number of fish which were on the line.

On the morning of the next day, the 9th, we saw on our starboard side a large school of fish at the surface accompanied by birds, but we did not fish it. We continued southward and at 7:30 A.M. on the 10th we began our third set. (This was a daytime fishing trial; in our later trials we tried to do all of our fishing at night.) From the sea conditions and other considerations we expected to make no catch at all, and consequently we set only 50 baskets of line. The catch was unexpectedly large - 4 yellowfin, 3 spearfish, and 3 sharks - and the weight of the fish which were taken was very encouraging. The set was made at a position near the entrance to the strait between the Solomons and the Santa Cruz Islands, and it is believed that the good results obtained were due to the fact that this strait is a broad highway for migrating fish. It is thought that if, for example, 200 baskets were set every day at dawn and at dusk, this vessel could be loaded to her full capacity of 15,000 kan [approximately 62 tons] in not more than a little over 10 days, and that without much necessity for moving around to different fishing grounds.

Our vessel reached $9\frac{1}{2}^{o}$ south latitude (it was against regulations to go farther south than 11^{o}) and we were able to find good fishing grounds, which made all hands feel cheerful as we turned our course toward the Gilbert Is., scheduling four fishing stations along the way.

The fourth set was begun at 3:30 A.M. on the 11th. There was lightning to the east-southeast, the cloud cover was 9, wind force 4, and the wind was slightly south of east. There was an east-northeast current with a velocity of approximately 2 knots. After setting the line we lost sight of it and spent about two hours searching for it. We made a good catch of 13 yellowfin, 2 big-eyed, 1 albacore, 3 spearfish, and 2 sharks. The sharks taken were fewer than we had expected, and although the line was in the water a long time none of the fish were damaged by shark bite. The taking of an albacore was of especial interest. The catch was about equally distributed among the various baskets of line. The spearfish which were hooked tangled up the line and from this circumstance it was easily possible to tell in advance while hauling in the line that one of these fish was on it.

The fifth station was fished beginning at 3:00 P.M. of the same day. This test was made in order to ascertain whether or not this area is closely related to the migratory path between the Solomons and the Santa Cruz Is. The catch comprised 5 yellowfin, 1 big-eyed, and 1 shark, and the fish were evenly distributed along the lines. The catch was smaller than we had expected. While hauling the lines we were visited by

squalls from time to time and the wind force got up to 4. I observed at this time that the two searchlights on the bridge were not much help to those who were working on the main deck, and I thought that it would be more advantageous to place lights on the forward part of the saloon so that they could aid the operations without shining too strongly into the fishermen's eyes.

On the following day, the 12th, at 3:15 P.M. we took skipjack on the trolling lines on both sides of the boat. One weighed 1 kan 500 momme [12.4 pounds] and the other weighed 1 kan 100 momme [9.1 pounds]. At this time the cloud cover was 10 and the color of the sea water was somewhat unfavorable.

On the 13th at 4:00 A.M. we began our sixth set about 200 miles south of Nauru. Two yellowfin (two more got away as they were being hauled in), 4 big-eyed, 2 spearfish, 3 sharks, and one skipjack were taken. The condition of the fish on the lines was in general as follows: (a) The various tunas showed some tendency to congregate. (b) The stomachs of the sharks were empty. (The sharks caught at the third set even had pieces of wood and spearfish spears in their stomachs.) One small skipjack was almost all that was found in the stomachs of the spearfish. Judging from these facts, the waters of this area appear to present truly pelagic conditions. (c) Weather and sea conditions at the time the lines were set were thought to be extremely favorable for fishing, but the poor catch ratio contradicted our expectations. (d) As far as currents are concerned, we appeared to be following the main stream of the Equatorial Current. (e) The vertical distribution of water temperatures at last was tending to become normal. (The matters considered in (c) and (d) come within the scope of the preceding section but they are inserted here for convenience' sake.)

On the 14th at 10:00 A.M. one skipjack bit on the trolling line, but it got away. Immediately afterward a large number of skipjack were seen jumping. At 3:00 P.M. the seventh set was made 40 miles southeast of Ocean I. In this trial, as reported at the beginning of this section, our entire catch comprised 29 yellowfin. I imagine that these fish could not be considered to be yellowfin which regularly inhabit the waters around Ocean I., but they were more likely part of a migratory school.

On the morning of the 15th we circled Ocean I. at about 3 miles distance and encountered a school of skipjack in the vicinity.

The following day at 10:00 A.M. we took one skipjack on the trolling line. It was somewhat smaller than those which we had taken before. [The same day we took a dolphin which was] 120 cm long and 3 kan 300 momme [27.3 pounds] in weight. Beginning at 2:50 P.M. of the same day we ran our eighth (and final) fishing station about 20 miles west of Tarawa in the Gilberts. The results were not expected to be very good, but whether it was because of the abundance of microscopic life in the water or for some other reason, the fishing was quite successful, 11 yellowfin, 2 big-eyed, and 5 sharks being taken. The most remarkable thing about this catch was the 43 kan spearfish which was mentioned above. Another thing was the shark problem. Thinking it over now, it seems that a shark fishery in the waters south of Jaluit could be

operated to greater advantage by using pole and line gear (with chumming bait) than with longlines. Of course if this method were used in conjunction with longlines it would be ideal. I hope at some time in the future to study the use of fishing lights and some other matters.

From our last position we proceeded directly to Jaluit where we arrived the night of the 18th. On the way we caught one skipjack on the trolling line at 11:00 A.M. on the 17th, and another at 8:00 A.M. on the 18th, which gives some indication of the commercial possibilities of the skipjack fishery in this area. Otherwise there was nothing remarkable to report.

Notes:

1. Longitudes and latitudes given are those determined accurately by celestial observations.
2. Oceanographic and meteorological observations were made either from the wheelhouse or from the deck above it.
3. Oceanographic observations were made after the lines were set in cases where the sets were made in the morning. When the set was made in the evening, observations were taken at the end of the line after it was set.
4. The direction and force of the current were determined from the track of the ship.
5. Sea water temperatures were taken with a stick-type thermometer. Salinities were determined with an Akanuma hydrometer and converted in accordance with the Reference Tables for Oceanographic Investigations.
6. The stray angle of the cable was not measured.

1. Table of Observations Made at Each Fishing Station

No. of Station	1	2	3	4
Date	5-6	5-8	5-10	5-11
Latitude	0°35'S	6°05'S	9°00'S	7°01'S
Longitude	166°30'E	164°26'E	163°30'E	165°15'E
Distance from shore	6 mi. SE of Nauru	---	---	---
Weather	bc	o. d	b	bc. q
Atmos. pressure	754.2	754.3	755.0	753.5
Atmos. temperature	28.4	27.5	28.5	28.1
Wind direction	NE/N	NNE	E	E/S
Wind force	2	2	3	4
Clouds, type	Cu	Nb	Ci, Cu	Cu, Ci
Cloud cover	4	10	4	5
Sea conditions	smooth	smooth	smooth	moderate swell
Current direction	W	ENE	ENE	ENE
Current force	1	1	3(1.3 mi/hr)	3(1.3 mi/hr)
Transparency	15.5m	24.0m	19.0m	18.0m
Water Temperature (°C) Surface	27.9	28.8	28.5	28.8
25 m	27.9	28.7	28.6	28.7
50 m	27.8	28.8	28.8	28.7
75 m	27.7	28.8	--	--
100 m	--	28.8	28.5	28.7
150 m	--	--	--	--
200 m	--	26.2	--	26.4
Salinity (‰) Surface	35.52	34.56	34.57	34.94
25 m	35.91	34.78	34.74	35.05
50 m	35.62	34.70	34.81	34.67
75 m	35.62	34.81	--	--
100 m	--	35.33	35.21	35.30
150 m	--	--	--	--
200 m	--	36.11	--	35.34

1. Table of Observations Made at Each Fishing Station (Cont'd.)

No. of Station	5	6	7	8
Date	5-11	5-13	5-14	5-16
Latitude	6°05'S	3°48'S	1°03'S	1°20'S
Longitude	165°55'E	166°28'E	170°21'E	172°30'E
Distance from shore	--	--	40 mi. E of Ocean I.	30 mi. W of Tarawa
Weather	o. q	b	c. q	o
Atmos. pressure	751.5	753.8	751.5	752.5
Atmos. temperature	27.9	28.6	28.2	27.2
Wind direction	ENE	ENE	SE	ENE
Wind force	1	3	2	3
Clouds, type	Nb,St,Cu	CiCu	Ci,Cu,A.Cu. CiCu	Nb,Cu,CuNb
Cloud cover	9	3	6	9
Sea conditions	smooth	slight swell	smooth	slight swell
Current direction	ENE	W	E	ENE
Current force	2	1	2	3(1.5 mi/hr)
Transparency	--	19.0 m	19.0 m	17.0 m
Water Temperature (°C) Surface	28.9	27.7	28.2	27.7
25 m	--	28.5	--	27.4
50 m	--	28.6	27.9	27.2
75 m	--	28.4	--	--
100 m	--	28.3	28.0	27.0
150 m	--	28.0	--	26.3
200 m	--	27.1	26.0	24.4
Salinity (‰S) Surface	--	35.59	35.79	35.44
25 m	--	35.79	--	35.59
50 m	--	35.95	36.04	35.52
75 m	--	35.99	--	--
100 m	--	35.96	35.95	35.56
150 m	--	35.82	--	35.56
200 m	--	35.88	36.39	35.55

2. Table of the Results of Fishing at Each Station

Station	1	2	3
Date	5-6	5-8	5-10
Latitude	0°35'S	6°05'S	9°00'S
Longitude	166°30'E	164°26'E	163°30'E
Began setting	0540	0300	0730
Finished setting	0640	0404	0815
Time required to set	1:00	1:04	0:45
Began hauling	0804	0620	0855
Finished hauling	1000	0830	1040
Time required to haul	1:56	2:10	1:45
Time gear fished	3:20	4:26	2:25
Direction gear set	SSW	SSE	SSE
Type of gear used	longlines	longlines	longlines
Number of baskets	60	60	50
Number of hooks	360	360	300
Bait used			
Sardines	120	180	250
Herring	120	120	25
Squid	120	60	25
Catch			
Yellowfin		14	4
Big-eyed			
Albacore			
Spearfish	5	1	2
Swordfish	1(juvenile)		
Sailfish			1
Shark	2	11	3(1 blue shark)
Other			
Shark-bitten		2(yellowfin)	
Tunas			
Total fish taken	6	15	7
Catch ratio (%)	1.7	4.2	2.4
Total weight (kan)	55.900	145.600	70.900
Average weight (kan)	11.180	9.707	10.129
Average length (meters)	1.64	1.25	1.50

/TN. 1 kan = 8.27 pounds. The "catch ratio" is the number of fish taken per 100 hooks fished./

2. Table of the Results of Fishing at Each Station (Cont'd.)

Station	4	5	6
Date	5-11	5-11	5-13
Latitude	7°01'S	6°05'S	3°48'S
Longitude	165°15'E	165°55'E	166°28'E
Began setting	0325	1545	0400
Finished setting	0420	1630	0445
Time required to set	0:55	0:45	0:45
Began hauling	0755	1720	0630
Finished hauling	1050	1945	0900
Time required to haul	2:55	2:25	2:30
Time gear fished	6:30	3:15	3:15
Direction gear set	NW/N	NNW	N
Type of gear used	longlines	longline	longlines
Number of baskets	65	60	60
Number of hooks	390	360	360
Bait used			
Sardines	325	300	300
Herring	35	30	30
Squid	30	30	30
Catch			
Yellowfin	13	5	2
Big-eyed	2	1	4
Albacore	1		
Spearfish	3		2
Swordfish			
Sailfish			
Shark	2	2	3
Other			1 skipjack
Shark-bitten			
Tunas			
Total fish taken	19	6	8
Catch ratio (%)	4.9	1.4	2.3
Total weight (kan)	170.750	49.100	91.000
Average weight (kan)	8.987	8.183	11.375
Average length (meters)	1.30	1.17	1.33

2. Table of the Results of Fishing at Each Station (Cont'd.)

Station	7	8	Total
Date	5-14	5-16	
Latitude	1°03'S	1°20'N	
Longitude	170°21'E	172°30'E	
			8 sets
Began setting	1500	1450	4 morning sets
Finished setting	1540	1530	1 daytime set
Time required to set	0:40	0:40	3 evening sets
Began hauling	1650	1700	
Finished hauling	1930	1940	
Time required to haul	2:40	2:40	
Time gear fished	3:50	4:10	29:91
Direction gear set	NNW	S/E	
Type of gear used	longlines	longlines	longlines
Number of baskets	60	60	475
Number of hooks	360	360	2,850
Bait used			
Sardines	300	300	2,075
Herring	30	30	420
Squid	30	30	555
Catch			
Yellowfin	29	11	78
Big-eyed		2	9
Albacore			1
Spearfish		2	15
Swordfish			1
Sailfish			1
Shark		5	28
Other			1
Shark-bitten			2
Tunas			
Total fish taken	29	15	105
Catch ratio (%)	8.1	4.2	3.6 average
Total weight (kan)	250.200	190.500	1,023.950
Average weight (kan)	8.628	14.654	
Average length (meters)	1.20	1.36	

3. Lengths and Weights of the Fish Taken

Notes: 1. The length is the distance from the mandible to the caudal peduncle expressed in meters.

2. The weight given is the weight after all of the viscera have been removed.

Station 1

	Weight (kan)	Length (m)
Spearfish	10.600	1.60
"	11.600	1.70
"	12.100	1.60
"	11.000	1.70
"	10.600	1.60
total	55.900	
average	11.180	1.64

[TN. 1 kan = 8.27 pounds.]

Station 2

Yellowfin	9.100	1.20
"	9.100	1.20
"	9.600	1.20
"	9.400	1.10
"	6.600	1.10
"	11.600	1.40
"	10.400	1.30
"	10.200	1.30
"	7.800	1.20
"	8.600	1.20
"	8.600	1.20
"	7.900	1.15
"	8.600	1.20
"	14.700	1.40
Spearfish	13.400	1.60
total	145.600	
average	9.707	1.25

Station 3

Yellowfin	9.600	1.30
"	0.100 [?]	1.30
"	8.100	1.90
"	8.100	1.20
Spearfish	8.500	1.70
"	13.000	1.30
"	13.500	1.80
total	70.900	
average	10.129	1.29

Station 4

	Weight (kan)	Length (m)
Yellowfin	8.600	1.20
"	8.100	1.20
"	9.100	1.20
"	9.600	1.25
"	9.100	1.20
"	7.700	1.20
"	12.600	1.40
"	8.300	1.20
"	10.000	1.30
"	11.100	1.30
"	8.600	1.30
"	8.150	1.30
"	6.600	1.20
Albacore	4.100	1.00
Big-eyed	6.500	1.20
"	6.100	1.15
Spearfish	13.600	1.70
"	11.500	1.70
"	11.500	1.70
total	170.750	
average	8.987	1.30

Station 5

Yellowfin	11.400	1.30
"	8.600	1.20
"	8.400	1.20
"	8.700	1.20
"	7.900	1.20
Big-eyed	4.100	0.90
total	49.100	
average	8.183	1.17

Station 6

Yellowfin	9.000	1.20
"	8.100	1.20
Big-eyed	6.600	1.10
"	7.100	1.00
"	8.100	1.10
"	6.100	1.00
Spearfish	13.500	1.80

3. Lengths and Weights of the Fish Taken (Cont'd)

Notes: 1. The length is the distance from the mandible to the caudal peduncle expressed in meters.

2. The weight given is the weight after all of the viscera have been removed.

Station 6 (cont'd.)

	Weight (kan)	Length (m)
Spearfish	32.500	2.20
total	91.000	
average	11.375	1.33

Station 7

Yellowfin	8.100	1.20
"	9.100	1.20
"	7.600	1.20
"	9.100	1.20
"	9.800	1.20
"	8.600	1.20
"	8.600	1.20
"	8.100	1.20
"	6.400	1.15
"	8.800	1.20
"	8.900	1.20
"	8.100	1.20
"	9.100	1.20
"	8.600	1.20
"	8.600	1.20
"	9.100	1.23
"	8.600	1.23
"	8.700	1.23
"	9.000	1.20
"	9.400	1.20
"	8.800	1.10
"	8.100	1.15
"	9.600	1.30
"	9.300	1.20
"	8.200	1.20
"	7.600	1.20
"	8.300	1.20
"	9.300	1.20
"	8.700	1.25
total	250.200	
average	8.628	1.20

Station 8

	Weight (kan)	Length (m)
Yellowfin	8.600	1.20
"	9.600	1.20
"	8.900	1.20
"	7.600	1.20
"	8.400	1.20
"	10.300	1.30
"	9.100	1.20
"	9.300	1.20
"	9.100	1.30
"	7.600	1.20
"	17.100	1.30
Big-eyed	15.600	1.40
"	10.100	1.20
Spearfish	17.200	1.80
"	42.000	1.50
total	190.900	
average	12.386	1.36

4. Trolling Catch and Other Reference Data (The times given are Jaluit time.)

Date	Time	Species	Number	Remarks
5-2	7:00 A.M.	skipjack	2	Hooked on two lines at the same time but got off.
5-5	8:00 A.M.	"	1	Weighed about 1 kan [8.27 pounds]; nothing in stomach.
5-5	11:00 A.M.	"	4	Two hooked at once twice, one got off. All about 1 kan, stomachs empty.
5-5	10:00 A.M.			Large school of porpoise sighted 2 miles off the starboard bow (whales also present).
5-12	3:15 P.M.	skipjack	2	No school in sight but 2 hooked at once. Both fat, weights 1.5 kan and 1.1 kan.
5-14	10:00 A.M.	"	1	Got away at the ship's side. Wind E/N force 3, cloud cover 8.
5-15	9:00 A.M.			Pretty large school 3 miles off Ocean I. Probably skipjack, not well surfaced.
5-16	10:00 A.M.	skipjack	1	About 0.8 kan weight. Wind NE force 3, cloud cover 10, slight swell.
5-16	2:00 P.M.	dolphin	1	Taken near Tarawa I. Had eaten 2 flyingfish, 1 small skipjack, 1 small squid, 1 other fish. Weight 3.3 kan. Female. Wind NE force 3. Cloud cover 10. Slight swell.
5-17	9:00 A.M.	skipjack	1	Got away.
5-17	11:00 A.M.	"	1	About 1 kan.
5-17	4:30 P.M.	"	2	About 0.8 kan. Three specimens of small skipjack collected from them.
5-17	5:00 P.M.	"	1	Got away.
5-18	7:20 A.M.	"	1	Weight 2.7 kan. Two fish and one squid in stomach.

Preservation and Disposition of the Catch

When tunas and sharks, which formed the major part of the catch, were on the line, the main line was pulled in by means of a line hauler. Two or three fishermen were stationed at the side-port (gangway) to detach the sections of line. One of these men would bring the fish in to the side of the boat, and another one or two of them would haul the fish aboard with a gaff-hook.

Fish of over 10 kan [about 80 pounds] in weight which were still lively had to be hoisted aboard with a winch. Even in the case of fish below this weight, and when handling sharks, it was more effective and faster to get them safely into the boat by using the winch. Once the fish were on deck they were struck two or three hard blows with a mallet on the top of the skull or the upper jaw. While they were stunned the hooks were removed. Then the sharks and the tunas were laid out separately on the deck.

When a good number of them were on deck, or the sun's rays were strong, or the temperature was especially high, it was necessary to stow the fish within about thirty minutes or as soon as possible. The reason for this is that the so-called "burning" of the fish can take place in less than one hour after capture.

The preparation of the fish was extremely simple. In the case of the tunas a 3 to 4 inch cut was made with a large knife just posterior to the anus, the viscera were loosened from their attachments, and the whole digestive tract was drawn out through the gill openings. The fish was then well washed with sea water and prepared for immediate stowage in the cold storage space. In the case of sharks the head was removed and the animal was eviscerated. Then the fins and tail were cut off. The carcass was washed with sea water and immediately stowed in cold storage in such shape that it could be opened up the back later so that the hide and flesh might be utilized. The lengths and weights of the tuna were recorded before they were thrown into the fish-hold. No such record was made for the sharks, but it is thought that an average weight of 7 kan would not be far off the true figure. This procedure for handling the fish was the same whether few or many were taken, and skipjack and dolphin which were taken were treated in the same way as the tunas.

As for the refrigeration equipment of the vessel, I had heard that in the South Seas fishery investigations of 1938 the imperfection of this equipment was responsible for the failure of the expedition, and therefore before leaving Japan a great deal of emphasis was placed on its repair. At present it can freeze 14 tons per day and make 7 tons of ice, truly an excellent capacity for a fishing boat of the 200-ton class. The direct expansion ammonia refrigerating unit keeps the cold storage hold at -16° C. and the freezing compartment at -37° C. while freezing and transporting 15,000 kan of fresh fish. During this voyage there was not the slightest trouble with this equipment and it did good work from beginning to end in the freezing and holding of the catch, and the preservation of perishable foods and drinking water. At first the fish

were placed temporarily in the cold storage hold and later moved into the freezing compartment by means of a communicating door between the two compartments, but as we made more fishing trials we adopted the practice of putting the fish directly into the freezing compartment.

Before leaving port the vessel loaded three tons of ice to supplement the capacity of the refrigeration machinery and to provide for other eventualities, but in view of the excellent performance of the installation this turned out to have been a useless precaution. The same thing could be said of a spare flask of ammonia which was taken along. But considering the demonstration of the ideal character of the equipment of this vessel, this circumstance must be said to be rather a cause for rejoicing than otherwise.

Conclusions

The general view is that what are called the South Pacific fisheries of the southern latitudes extend from the waters off Kenya Colony in Africa on the west to the southern islands of the Hawaiian group on the east. Now I would like to make a number of observations concerning our so-called South Pacific fishery investigations in the waters south of the Marshalls, but in view of the extremely small area covered by these investigations I am truly embarrassed. I am, however, emboldened to attempt to draw these conclusions since I think that, from the point of view of fisheries, all sea areas have a good many essential features in common such as weather and sea conditions, the occurrence of fish, and the handling of the catch, and from conditions in one area it is easy to deduce conditions in another.

Naturally these conclusions are not based solely on the data reported in the present paper, but draw also on my Report of Fishery Investigations in the South Seas (published by the Ministry of Colonies), Report of Fishery Investigations in the Dutch East Indies (published by the South Seas Government-General), and other sources. Therefore it will be useful to consult the reports which I have mentioned and also other publications of the Ministry of Agriculture and Forestry and other governmental organizations concerned.

The following is an effort to present all of the essential data, but since many of these subjects have already been explained as fully as possible under the appropriate sections only the main points will be included here.

1. The principal problems which arise in connection with the weather

In the low latitudes weather forecasts are comparatively accurate and it is easy to determine what the weather is going to be. This fact can be fully substantiated by referring to the accuracy of predictions made by persons who have had many years of experience in navigating those waters and by the aborigines (on this expedition we consulted the predictions made by the natives of Ebon I.). Consequently once you begin to have confidence in these predictions they are extremely significant from

the fisheries standpoint. In general it may be said that low pressure areas do not arise in those waters and that the highest winds are of force 5 or 6. Winds of force 7 do occur, but only as an extremely temporary phenomenon. As far as this point is concerned fishing vessels of 100 tons could probably operate in the area without mishap.

There is, however, the drawback that because of the high temperature which prevail all year round, bases and comparatively large vessels equipped with refrigeration facilities are necessary. In view of the fact that the whole catch consists of perishable foodstuffs, insofar as there is no market where it can be quickly consumed deep thought must be given to its handling. For fishing off the Midway Is. a base in the Marshalls would cut in half the direct cruising distance from Japan, and there is a tendency to advocate strongly the importance of such a base, but the reasons why I cannot immediately agree with this proposal are at present founded mainly on this point. The solution of this problem is predicated upon the establishment of the refrigeration facilities mentioned above and upon the existence of clear prospects with regard to marketing channels.

Large quantities of rain fall in the so-called squalls and it is essential that changes be made in the construction of the boats so that the rain water will run of its own accord into their fresh water tanks. My friend Mr. Minoru Yamamoto, first engineer on the Nippon Yūsan ship on which I went to Jaluit, was successful in catching water in this manner while moored in Kusaie Harbor. If this can be done aboard a merchant vessel, and if, as everyone knows, it is necessary at all of the islands to have fresh water tanks for catching rain, how much more pressing is the need for such arrangements on fishing vessels where fresh water is a particularly vital necessity.

At all positions during this voyage we saw lightning frequently. According to the radio operator there was a lot of static and it was impossible many times to make the scheduled contacts with our base. Since this happened repeatedly, one cannot help wondering whether there is not some sort of direct cause and effect relationship between the lightning and our present radio equipment. Vessels of the 200-ton class which operate in comparatively distant waters should be fully equipped with radio communications facilities.

2. The principal problems arising from sea conditions

There is a theory that, because the sea is calm and the currents slow, small fishing vessels (20-ton class) should be constructed, but I cannot immediately agree with this idea either. Its proponents seem to point out the fact that simply by using small vessels the expense of operation will be cut down. If that were so the best thing to do would be to go a step further and build a large number of canoes from materials which could be obtained in the area. Even at present the natives and Japanese residents who take an interest in fishing are catching not only yellowfin but even sharks and spearfish weighing 20 or 30 kan. For a number of reasons it is probably best to operate efficiently with vessels of the largest possible size. As far as sea

conditions are concerned, it appears that the most suitable boat for all kinds of tuna longline fishing at present is a vessel of standard design in the 95-ton class. If marketing conditions were good, the same thing would of course be true for the Marshall Is.

The newer types of longlines do not have long and short branch lines, all of the branch lines being of the same length. When using these lines in the seas of the low latitudes one has the feeling that the branch lines are a good deal too short. As explained at various places in this paper, the level at which the fish swim appears to be 30 or 40 fathoms down. As a result, if the fishing does not happen to be done in an area where the schools come up near the surface, one can only wish for longer branch lines. It is not, of course, required that the length of the branches should be approximately the same as the depth of the level at which the fish swim.

Places where the water flows in and out unceasingly between islands and archipelagos, and sea areas which can be thought to be directly or indirectly related to such places are good fishing grounds. On this cruise we had this experience between the Solomons and the Santa Cruz Is., but this fact has also been recognized previously in the Andaman-Nicobar area of the Indian Ocean, the so-called Eastern Archipelago east of Sumatra and Java, and in other areas.

A related question is that of the angle at which the lines should be set with relation to the current, and this must be left to the operator's own judgment. The question of whether to haul the lines from upwind or downwind was one of the problems in fishing gear operation which we studied during this voyage. In general it may be said that it is better to haul from the downwind side, but in case the wind is light it may perhaps be more reasonable to haul from the upwind side.

Since the sea is calm it would probably save a great deal of trouble if a tender (in my opinion it should be a vessel of 3,000 tons or more) were employed to carry supplies and transport the catch for large and small boats on the fishing grounds. For many years I have been discussing and advocating the use of fishing flotillas, and I think that if tenders were employed as floating bases, the fishing operations would become surprisingly easy. In order to do this, however, the problem of marketing channels and many problems related to operating such an enterprise would first of all have to be solved.

3. The main problems arising from the fish

Among the forms of marine life in these waters, without making a complete list, we may cite as most abundant the various tunas, skipjack, cybiids, squid, shark, sardines, various shellfish, turtles, Decapterus spp., and sea cucumbers. Those which show the most immediate prospects for profitable exploitation are the tunas, skipjack, sharks, and flying-fish, and we can expect a steady expansion of commercial fishing for these species in the future. Because of the high water temperatures, the culture of various kinds of shellfish should be practicable, but the return on one's investment in such enterprises is comparatively slow and the area of suitable land available is limited. For these

reasons they probably cannot be operated as large-scale individual enterprises nor by persons who wish to make a quick profit. The species which are the object of the fisheries of which I have been writing, and particularly of the tuna fishery, are, as set forth at the beginning of this section, distributed evenly over a wide expanse of ocean from Africa on the west, southern Hawaii and the Americas on the east, and eastern Australia and New Caledonia on the south. When a world market is developed for processed products from these fisheries (a problem which the Ministry of Agriculture and Forestry and others have under study at present), it is clearer than daylight that entrepreneurs will flock into the field. A point to be considered here is that after the China Incident many Japanese will emigrate to China and there will be a possibility of exporting suitable processed fisheries products to the Continent. For this reason I believe that the real exploitation of this field will not appear until two or three years have passed.

The fishery for sharks by pearling boats during the off-season, which is being carried on at present and which has recently been loudly advocated, is thought probably to be profitable when only the sharks of the shore waters near the base of operations are fished, but I have doubts as to whether it can be carried on when operations are extended into more distant waters. The reason for this is that even in the case of sharks there are such things as fishing seasons and good fishing grounds. This fishery must either be run in conjunction with the tuna longline fishery, or else further study must be made with regard to fishing methods.

Finally we come to the skipjack fishery, which at present is on a comparatively solid basis as the fishery par excellence of the South Seas. The skipjack fishery based in the islands is, for a number of reasons, thought to be probably limited to a certain fixed level of expansion. As noted elsewhere in this report, it is thought that an industry three times the size of the present one would probably have reached the saturation point.

4. The principal problems arising from the handling and transportation of the catch

The procedure to be followed in handling the fish themselves has already been outlined. What I want to take up here is the problem of transportation. Since these waters are far from Japan and from consumer markets in foreign countries, a suitable base of operations must be sought. I have a plan of my own concerning this matter, and after further examining it for some time I wish to present it to my readers for their criticism. If so-called tenders are not used, the largest possible transport vessels should be employed, preferably ships over 500 tons.

5. The principal general problems

A. The problem of food for the crews

Because of the high temperatures which prevail everywhere in the area there is an abundance of delicious fruit; however, it is impossible to raise vegetables in many places because of the lack of good soil. Since vegetables are the most important staple food in the crew's diet, vessels going to such areas must make preparations in advance to avoid spoilage. Some kinds of suitable produce can probably be obtained in each area.

The demand for sugar is high and some preparations must be made to supply it in various forms because it is a source of energy. This was the case on the research vessel, and it must be even more so on a regular working vessel where over-exertion is unavoidable. The need for alcoholic beverages is extremely limited and does not require any general consideration. During my recent tour of duty not one of the young fishermen or engineroom men asked for liquor, an interesting fact which bespeaks a change in the times.

As a result of eating fish guts from the catch cooked with miso half of the crew suffered from vomiting and diarrhea (with headaches and bellyaches). They all recovered fully within three days. In the low latitudes bellyaches, even when not caused by food, are of frequent occurrence, and it is essential to be prepared with medicines against them. During the course of the operations one man hurt his leg. Accidents like this happen from time to time and it is important to have ointments to apply in such cases.

B. Problems of the crew's welfare and recreation

Some sort of recreational facilities are necessary in these isolated areas where the climate is unfavorable. On this cruise all of the members of the crew were picked men, and we benefited by their harmonious cooperation. On thinking it over thoroughly, however, these good results were due to the fact that we had gathered together the most excellent men from various areas. But this is something apart from the problem of recreational facilities. The leaders must study this problem in advance and set up appropriate facilities both aboard ship and at the base. Aboard ship suitable books should be provided, combining the objectives of recreation and ideological guidance, and the men should be given the opportunity to listen to the radio and phonograph. At the base they should by all means be given a chance to rest in comfortable beds, and encouraged to take walks and exercise. After our return to Jaluit the Chief of the District Office invited me to have the crew sleep at the Japanese Club, a favor for which I can never thank him enough. We were, however, so busy putting in order the materials left over from what we had brought out the year before that on this cruise we could only give the crew one day of rest aboard the ship. (end)

Note: With the publication of this report in this journal taking place a full year after the investigation which it describes, one cannot help feeling some regret at its tardiness, however, one cannot but feel, on the other hand, that the material is timely in view of the fever for southward expansion which is gripping our fishing industry. On the basis of this paper Mr. Kenzō Ikebe of the South Seas Government-General Fisheries Experiment Station has stated in South Seas Fishery News, Volume 4, Number 2, that "the greater part of the catch consists of fish in their seventh year, and fish older and younger than that are taken only occasionally. The yellowfin tuna of the waters adjacent to Palao and those of the waters south of the Marshalls are migratory fish belonging to the same stock." I wish to take this opportunity to offer my thanks to him, and also to Mr. Ōta, the editor of this journal, for publishing this paper.